1969

Kiln-drying different thicknesses of southern pine lumber

William C. Hopkins

Kiln-Drying Different Thicknesses of Southern Pine Lumber

W. C. Hopkins, E. T. Choong
and
P. J. Fogg

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURE EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR
IN COOPERATION WITH
SOUTHERN FOREST EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

ulletin No. 636

July 1969

Table of Contents

Summary

The primary objective of this study was to compare the drying time and amount of seasoning degrade of 3/4-inch and 6/4-inch southern pine lumber with that of 4/4-inch and 8/4-inch lumber when all thicknesses were dried by typical kiln schedules. Additional objectives were to gain an indication of the feasibility of drying the thinner lumber, and of the associated reduction in costs and increase in production.

One 90-piece charge of each of the four thicknesses was dried in an experimental kiln by each of three schedules. The schedules selected for the 3/4-inch and 4/4-inch lumber were the same (mild, AS11-BK6; moderate, AS11-AK6; and severe, AS12-AK8). Identical schedules were also selected for the 6/4-inch and 8/4-inch lumber (mild, AS10-AK4; moderate, AS11-AK6; and severe, AS12-AK8). Each piece of lumber was weighed, measured, and checked before and after drying for warping defects and shrinkage. Casehardening was also checked on 10 samples, and the degree of surface checking was measured on another 10 samples from each charge.

Generally, 3/4-inch lumber not only dried more rapidly than 4/4-inch lumber with the same schedules, but did so without any significant increase in drying defects. In the case of 6/4-inch lumber, however, the more rapid drying, especially under the most severe schedule, was accompanied by an increased amount and severity of drying defects. This result indicates the need for use of more moderate schedules for drying 6/4-inch lumber than for 8/4-inch lumber.

Kiln-Drying Different Thicknesses Of Southern Pine Lumber

W. C. Hopkins, E. T. Choong and P. J. Fogg*

Introduction

Present practice in the southern pine industry is to manufacture lumber in 4/4-inch and 8/4-inch thicknesses. For many uses, however, 3/4-inch and 6/4-inch lumber would be equally good, and substantial increases in the number of pieces and surface area obtainable from a given size log would result. For example, a 15-inch log sawed into 4/4-inch lumber by a saw taking a 1/4-inch kerf yields 12 boards. If the same log is sawed into 3/4-inch lumber with the same saw, it yields 15 boards. Also, the cost of kiln-drying should be substantially less with thinner lumber. A kiln of a given capacity holds 17 per cent more pieces of 3/4-inch lumber than of 4/4-inch lumber, when using 3/4-inch stickers. Presumably, too, it would take less time to dry the thinner pieces. Seventy-two hours is the minimum time required to dry 4/4-inch southern pine lumber in a modern dry kiln. In a year with 300 working days, 100 charges can be processed through a kiln. If the 72-hour drying time could be reduced to 64 hours, 112.5 charges could be processed. Since each charge would contain 17 per cent more pieces, kiln output over the year could be increased by 32 per cent.

This study was conducted to determine the feasibility of drying 3/4-inch and 6/4-inch lumber, from the standpoint of drying time and seasoning degrade, as a means of reducing manufacturing cost and increasing product yield without diminishing lumber quality.

Materials and Procedure

Kiln charges, three each of 3/4-inch, 4/4-inch, 6/4-inch, and 8/4-inch southern pine lumber, were dried in a steam-heated, internal-fan kiln at Louisiana State University. The experimental kiln was equipped with a recorder controller to maintain drying conditions called for in the drying schedule. The air flow, measured at the leaving-air side, was about 450 linear feet per minute. The air circulation was reversed at 4-hour intervals.

Each kiln charge consisted of 90 pieces of No. 2 Common or better, each 6 inches wide and 8 feet long. Six pieces in each charge were selected to provide moisture content samples. The kiln pile was made up of 12

*Former Professor (deceased), Associate Professor, and Assistant Professor, respectively, School of Forestry and Wildlife Management, Louisiana State University.

courses, 4 feet wide. Each course contained eight pieces. No space was left between the edges of the lumber, but courses were separated by 3/4-inch stickers placed on 2-foot centers. To prevent warping, especially in the upper courses, each charge was suitably weighted with iron bars to distribute a total weight of 4,000 pounds on the bottom layers. A typical charge, in place in the kiln, is shown in Figure 1.

The lumber for each charge was obtained at random from the green chain of a medium-sized sawmill in Southeast Louisiana. Pieces which included heartwood were excluded insofar as possible. Defects in individual pieces, such as checks or splits, were noted before drying so that degrade that developed during drying could be properly evaluated. Moisture content of the lumber for various charges ranged from 50 to 125 per cent.

In order to observe the process of drying, six end-coated samples, 30 inches long, were selected from the original supply of lumber for each kiln run. Three of the samples were placed on the entering-air side of the pile, the other three on the leaving-air side. On each side, these samples were located in the second, seventh, and eleventh courses (Fig. 2). Calculated oven-dry weights were computed from two 3/4-inch wafers sawed from one end of each sample. These values were used to determine the moisture content of the samples during drying by periodically reweighing the samples at each change in the drying schedule. A Pennsylvania scale was used to weigh each sample to the nearest one-hundredth of a pound.

Shrinkage and drying defects were evaluated by measurement of length, width, thickness, and warp of each piece of lumber before and after drying. The length of the piece was measured to the nearest thirty-second of an inch with a ruler, along a line extending from the mid-point of the width at one end to the mid-point of the width at the other end. The width and thickness of the board were measured to the nearest one-hundredth of an inch; the width was measured at the mid-point of the length, and the thickness at mid-length and mid-width. Warp was evaluated by measuring for maximum bow, crook, cup, and twist to the nearest thirty-second of an inch. Bow and crook were determined by placing the edge at either end of the piece against a taut wire and measuring the maximum perpendicular distance from the wire to the face and edge of the piece, respectively. Cup was determined by measuring the distance from a steel straightedge placed across the width of the lumber to its face. Twist was ascertained by holding three corners of the lumber down on a plane surface and measuring the distance from the surface to the other corner of the piece. The methods of measuring bow, crook, and twist are illustrated in Figures 3, 4 and 5, respectively.

In addition, 10 sample pieces, picked at random from each charge, were dressed on two surfaces to examine the extent of checking. A stress analysis was also made by sawing each of 10 randomly selected samples from each charge into two pieces and evaluating the nature of the stress (casehardening) developed after drying.

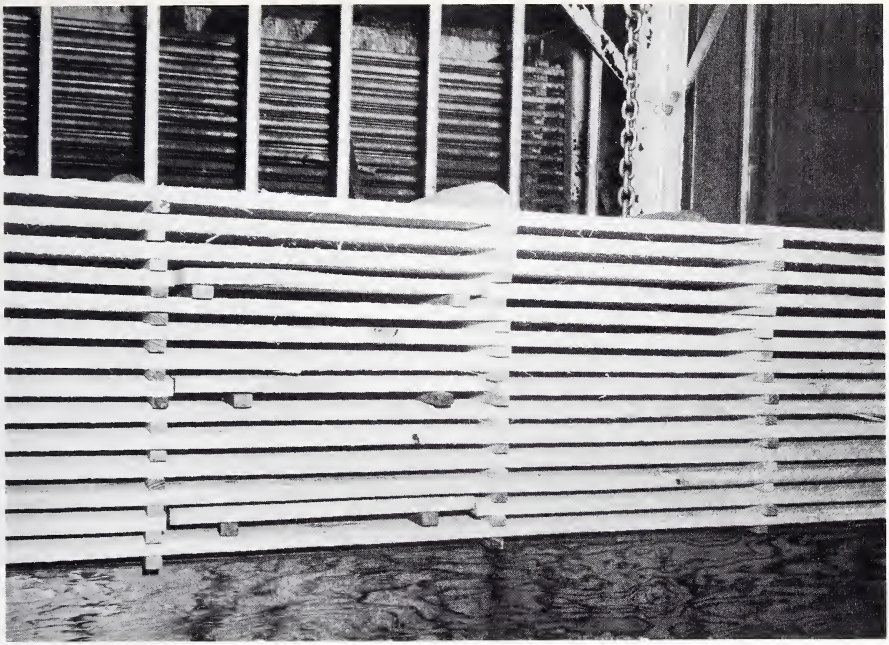

FIGURE 1.—Kiln charge in place.

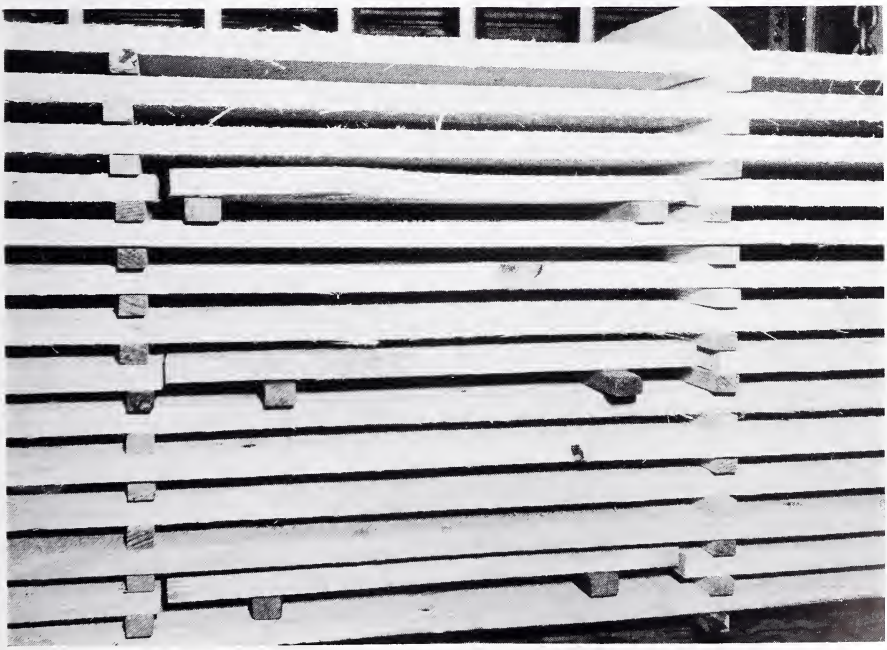

FIGURE 2.—Sample pieces in place in kiln pile.

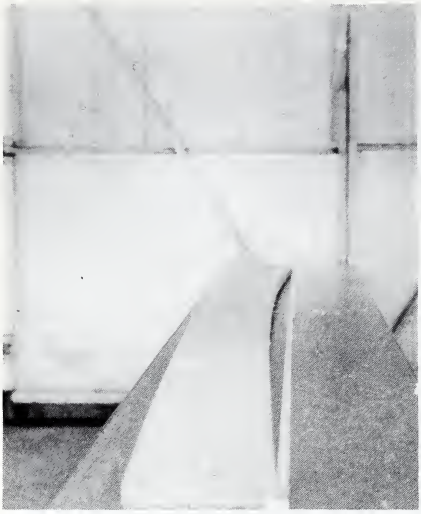

FIGURE 3.—Board in position for measurement of bow.

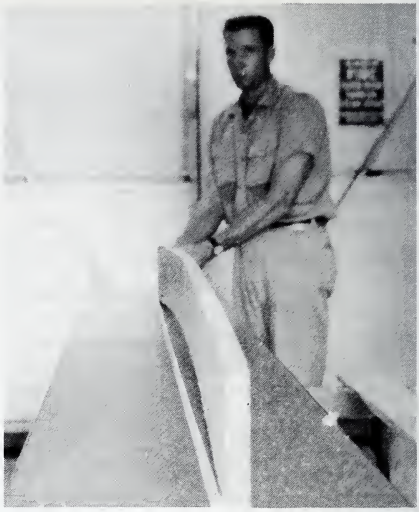

FIGURE 4.—Measurement of crook.

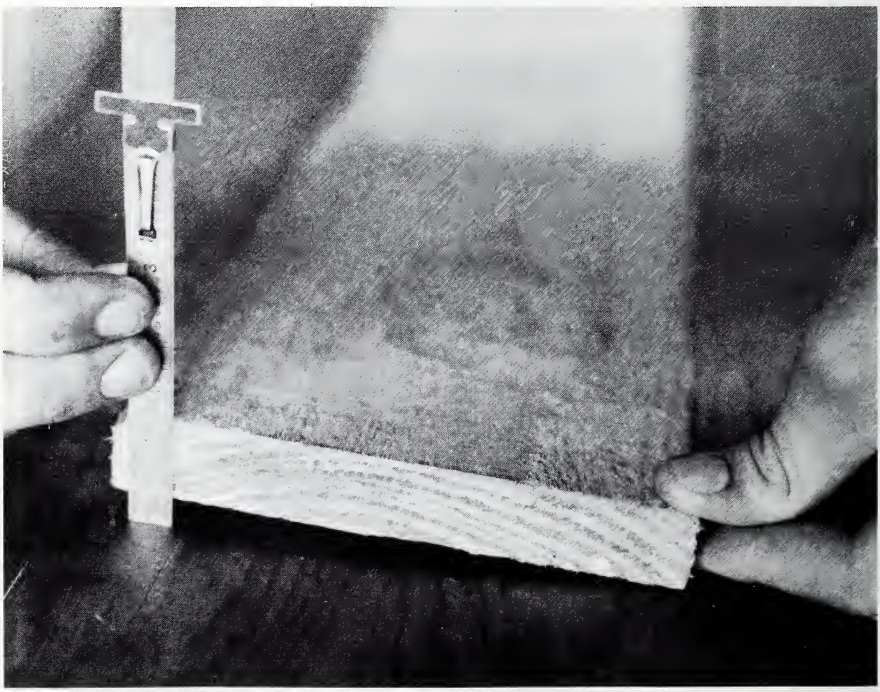

FIGURE 5.—Measurement of twist.

Kiln Conditions

Three different drying schedules were used with each thickness class, so that each schedule could be applied in a separate run. These schedules were obtained from a standard dry kiln manual.[1] Altogether, 12 different kiln runs were made. The code indices of kiln schedules for these runs are shown in Table 1.

The three drying schedules for 3/4-inch and 4/4-inch lumber are shown in Table 2. The first schedule (AS11-BK6) is an average commercial time schedule for upper grade 4/4-inch pine lumber, which ends with a 30° F. depression at 200° F. It is designed to achieve rapid drying under a relatively mild initial temperature condition. The second schedule (AS11-AK6) is intermediate in severity, requiring a more rapid change in depression. The third schedule (AS12-AK8) is the most severe, with a long period at 200° F. and a large (50° F.) depression.

The three drying schedules for 6/4-inch and 8/4-inch lumber are shown in Table 3. The first schedule (AS10-AK4) is an average commercial time schedule for upper 8/4-inch pine lumber. The second (AS11-AK6) and third (AS12-AK8) schedules are more severe than the first. They were designed with the objective of bracketing the ability of the 8/4-inch lumber to withstand rapid kiln drying while observing the effect on the 6/4-inch lumber.

Results and Discussion

Drying Rates

The various drying conditions attained and the rate-of-drying curves for each schedule-thickness combination (kiln run) are shown in Figures 6 through 17 (Pages 16-21).

TABLE 1.—Code Number Indices of Drying Schedules Used for Lumber of Various Thicknesses in Different Runs

Run no.	Lumber thickness	Drying schedule		
		Schedule	Code index	Severity
1	3/4	A	AS11-BK6	Mild
2	3/4	B	AS11-AK6	Moderate
3	3/4	C	AS12-AK8	Severe
4	4/4	A	AS11-BK6	Mild
5	4/4	B	AS11-AK6	Moderate
6	4/4	C	AS12-AK8	Severe
7	6/4	D	AS10-AK4	Mild
8	6/4	E	AS11-AK6	Moderate
9	6/4	F	AS12-AK8	Severe
10	8/4	D	AS10-AK4	Mild
11	8/4	E	AS11-AK6	Moderate
12	8/4	F	AS12-AK8	Severe

[1] E. F. Rasmussen (1961). Dry Kiln Operator's Manual, Agricultural Handbook No. 188, U. S. Department of Agriculture, U. S. Forest Service, Washington, D. C. 197 p.

TABLE 2.—Schedules for Drying 3/4-Inch and 4/4-Inch Pine Lumber

Time	Dry bulb temperature	Wet bulb depression	Wet bulb temperature
Hours		°F.	
		Schedule A (AS11-BK6)	
0-12	165	15	150
12-24	170	15	155
24-36	175	20	155
36-48	180	20	160
48-60	190	25	165
60-72	190	25	165
72-	200	30	170
		Schedule B (AS11-AK6)	
0-12	170	15	155
12-24	175	20	155
24-36	180	25	155
36-48	190	30	160
48-60	190	30	160
60-72	200	35	165
72-	200	50	150
		Schedule C (AS12-AK8)	
0-12	170	20	150
12-24	175	25	150
24-36	180	30	150
36-48	190	35	155
48-60	190	43	147
60-72	200	50	150
72-	200	50	150

The average drying time at various fractions of moisture in wood (E values) and the final average equilibrium moisture content (EMC) obtained are presented in Table 4. The time to reach E = 0 is somewhat superficial due to the effect of stress relaxation in wood under a constant environmental condition;[2] hence, E = 0.04, which represents 96 per cent of the moisture removed from the wood, should be a better indication of total drying time. For example, Figure 6 shows that the total drying time required to reach an EMC of 7 per cent is 84 hours; yet the drying time required to reach 8 per cent moisture at E = 0.04 is only about half as long (44 hours). It should take only an additional 12 hours for degrade control and equalization treatment.

In drying both 3/4-inch and 4/4-inch lumber, the drying rate (per cent moisture removed per hour) at E = 0.5 is slowest in schedule A, intermediate in schedule B, and fastest in schedule C. The drying rate for the thinner (3/4-inch) lumber is consistently faster than that for the thicker (4/4-inch) lumber, even though the drying time at E = 0.5 in schedule C is greater for the thinner lumber than for the thicker lumber.

[2]E. T. Choong and P. J. Fogg (1968). Movement of Moisture in Six Wood Species. Forest Products Journal 18(5):66-70.

TABLE 3.—Schedules for Drying 6/4-Inch and 8/4-Inch Pine Lumber

Time	Dry bulb temperature	Wet bulb depression	Wet bulb temperature
Hours		°F.	
		Schedule D (AS10-AK4)	
0-12	160	7	153
12-24	165	10	155
24-36	170	15	155
36-48	180	20	160
48-60	180	25	155
60-72	190	30	160
72-	190	35	155
		Schedule E (AS11-AK6)	
0-12	165	15	150
12-24	170	20	150
24-36	175	25	150
36-48	180	30	150
48-60	190	30	160
60-72	190	35	155
72-	200	50	150
		Schedule F (AS12-AK8)	
0-12	170	20	150
12-24	175	25	150
24-36	180	30	150
36-48	190	35	150
48-60	190	43	147
60-72	200	50	150
72-	200	50	150

This can happen because the E-value is a function of the initial moisture content of wood.

In drying 6/4-inch and 8/4-inch lumber, the drying rate at $E = 0.5$ is slowest in schedule D, and faster in both schedules E and F. The reason a moderate schedule (E) dries the 8/4-inch lumber faster than a more severe schedule (F) is probably due to the initial high wet bulb depression in schedule E (Fig. 16) followed by a lowering of this depression during the second stage of drying, when most of the free water in the wood near the surface has been removed. The effect of this kind of schedule on degrade was found to be less than that of the more severe schedule. A comparison of the drying rates for the two thicknesses shows that the thinner lumber tends to dry faster than the thicker lumber. The final equilibrium moisture content of these two lumber thicknesses, however, averages about 6 per cent higher than that of either the 3/4-inch or the 4/4-inch lumber, suggesting that the total drying time is actually longer than that indicated in Table 4.

Dimensional Change

Shrinkage in length, width, and thickness of lumber in terms of actual changes in dimensions from the green condition to moisture equilibrium

TABLE 4.—Drying Data for Pine Lumber of Different Thicknesses Dried with Different Schedules

Thickness class	Run no.	Schedule class	Avg. drying rate at E=0.5	Avg. drying time[1]			Avg. EMC
				E=0.5	E=0.04	E=0.0	
Inch			% MC/Hr.		Hours		%
	1	A	1.7	13	44	84	7
3/4	2	B	3.9	14	43	84	6
	3	C	4.2	15	40	72	3
	4	A	1.4	17	50	84	3
4/4	5	B	2.5	19	48	84	4
	6	C	3.7	12	42	72	4
	7	D	0.8	29	65	72	10
6/4	8	E	1.8	24	50	60	11
	9	F	1.8	22	43	48	13
	10	D	0.9	51	91	96	12
8/4	11	E	1.4	32	77	84	13
	12	F	1.2	32	76	84	10

[1]E is fraction of moisture in wood, which is the difference between current moisture content (MC) and equilibrium moisture content (EMC), divided by the difference between original moisture content and equilibrium moisture content.

are given in Table 5. These data are averages derived from measurement of 90 pieces of lumber in each kiln charge. Since the material consisted almost entirely of flat-sawed lumber, the width and thickness represent the tangential and radial direction of the grain, respectively. The effects of the drying schedule and thickness on shrinkage in the three directions were statistically analyzed (Table 6). With the exception of the shrinkage in length in the 6/4-inch and 8/4-inch stock, all shrinkage values were affected by the drying schedule. Furthermore, all shrinkage values except those in length in the 3/4-inch and 4/4-inch stock were also affected by the thickness of the lumber. Shrinkage in thickness of 3/4-inch lumber was 63 per cent of that of 4/4-inch lumber. There was less shrinkage in length and more shrinkage in width in 6/4-inch than in 8/4-inch lumber.

It is apparent from Table 5 that almost all shrinkage values in the 6/4-inch and 8/4-inch lumber were somewhat lower than in the 3/4-inch and 4/4-inch lumber, because the thicker lumber had a higher equilibrium moisture content. It is also shown in Table 5 that mild schedules (A and B) caused the least shrinkage in all of the three directions, whereas severe schedules (C and F) caused the most shrinkage. However, these differences were not great. The reason for these shrinkage differences is probably that large drying stresses occur when a schedule is severe, causing a great amount of set to develop in tension in the outer portion of the wood. The resultant effect is a large compression set in the inner wood, exerting a significant influence on total shrinkage.

Warp

Data on warping defects are given in Table 7. The effects of the drying schedule and lumber thickness on these defects were statistically analyzed (Table 8). In the 3/4-inch and 4/4-inch lumber, the more severe drying schedule (C) contributed to more bowing, crooking, and cupping than the less severe schedules (A and B); but the extent of

TABLE 5.—Shrinkage in Length, Width, and Thickness of Lumber During Kiln-Drying from the Green Condition

Schedule and thickness	Average shrinkage (green to EMC)					
	Length		Width		Thickness	
	Inch					
SCHEDULE A						
3/4-inch	.057	(0–.25)[1]	.270	(.13–.36)	.025	(0–.07)
4/4-inch	.072	(0–.25)	.284	(.15–.41)	.044	(0–.08)
SCHEDULE B						
3/4-inch	.062	(0–.38)	.356	(.17–.45)	.030	(0–.07)
4/4-inch	.076	(0–.11)	.321	(.17–.42)	.047	(0–.10)
SCHEDULE C						
3/4-inch	.151	(0–.53)	.345	(.19–.41)	.033	(0–.08)
4/4-inch	.119	(0–.46)	.370	(.13–.40)	.047	(0–.10)
SCHEDULE D						
6/4-inch	.046	(0–.28)	.153	(.03–.30)	.031	(0–.08)
8/4-inch	.076	(0–.59)	.066	(0–.34)	.023	(0–.09)
SCHEDULE E						
6/4-inch	.059	(0–.62)	.164	(.06–.32)	.042	(0–.09)
8/4-inch	.073	(0–.62)	.096	(0–.21)	.025	(0–.10)
SCHEDULE F						
6/4-inch	.067	(0–.28)	.153	(.03–.22)	.028	(0–.07)
8/4-inch	.078	(0–.69)	.146	(.06–.28)	.039	(0–.10)

[1]Ranges of values. In parentheses: first number is minimum, second number is maximum.

TABLE 6.—Effect of Schedule, Thickness, and Schedule-Thickness Interaction on Shrinkage in Length, Width, and Thickness

Independent variable	Shrinkage in		
	Length	Width	Thickness
3/4 and 4/4 lumber			
Schedule	**	**	**
Thickness	N.S.[1]	*	**
Interaction	*	**	N.S.
6/4 and 8/4 lumber			
Schedule	N.S.	**	**
Thickness	*	**	**
Interaction	N.S.	**	**

*Significant at 5% level of probability.
**Significant at 1% level of probability.
[1]Not significant.

TABLE 7.—Summary of Warping Defects Developed During Drying

Schedule and thickness	Warping defects (average value)							
	Bow		Crook		Twist		Cup	
	1/32nd inch							
SCHEDULE A								
3/4-inch	1.3	(−7, +14)[1]	2.6	(−3, +19)	2.8	(−3, +10)	1.4	(0, +4)
4/4-inch	−0.5	(−19, +13)	2.4	(−4, +20)	3.3	(−6, +16)	1.7	(0, +4)
SCHEDULE B								
3/4-inch	3.3	(−3, +36)	2.6	(−4, +29)	2.8	(−3, +12)	1.1	(0, +4)
4/4-inch	1.1	(−13, +13)	3.4	(−2, +35)	3.2	(−3, +23)	1.1	(0, +3)
SCHEDULE C								
3/4-inch	2.6	(−13, +24)	6.3	(−3, +40)	1.3	(−2, +8)	1.4	(0, +4)
4/4-inch	3.5	(−11, +23)	4.2	(−2, +42)	3.2	(−4, +14)	2.5	(0, +5)
SCHEDULE D								
6/4-inch	0.6	(−5, +11)	0.7	(−4, +10)	4.7	(0, +28)	0.6	(0, +3)
8/4-inch	0.3	(−6, +8)	0.9	(−4, +6)	2.1	(0, +10)	0.0	(0, +1)
SCHEDULE E								
6/4-inch	1.1	(−16, +23)	2.1	(−5, +27)	3.1	(−2, +32)	0.6	(0, +3)
8/4-inch	1.1	(−17, +9)	2.7	(−4, +25)	2.6	(−3, +21)	0.0	(0, +2)
SCHEDULE F								
6/4-inch	0.1	(−6, +10)	1.2	(−2, +21)	4.7	(−2, +15)	0.6	(0, +2)
8/4-inch	0.1	(−8, +9)	2.6	(−3, +36)	4.5	(−3, +20)	0.0	(0, +0)

[1]Ranges of values. In parentheses: first number is minimum (negative value indicates a decrease in the defect during drying); second number is maximum.

TABLE 8.—Effect of Schedule, Thickness, and Schedule-Thickness Interaction on Development of Bow, Crook, Twist, and Cup

Independent variable	Warping defects			
	Bow	Crook	Twist	Cup
3/4 and 4/4 lumber				
Schedule	**	**	N.S.	**
Thickness	*	N.S.[1]	**	**
Interaction	**	*	N.S.	**
6/4 and 8/4 lumber				
Schedule	N.S.	**	*	N.S.
Thickness	**	*	**	**
Interaction	**	N.S.	N.S.	N.S.

*Significant at 5% level of probability.
**Significant at 1% level of probability.
[1]Not significant.

twist was almost the same in all three schedules. In the 6/4-inch and 8/4-inch lumber, the severity of the drying schedule affected only crooking and twisting. Generally, more warp developed in the 4/4-inch lumber than in the 3/4-inch lumber. In the thicker group, the 6/4-inch lumber had greater seasoning degrade than the 8/4-inch lumber. Normally, warping is caused by differential shrinkage behavior in material that contains natural defects, such as knots or cross-grain, and is not solely

attributable to the atmospheric condition under which the wood dries if all boards are properly stacked. However, the severity of the drying schedule, especially when high temperature is involved, is closely related to set and shrinkage, which in turn affect the degree of warpage. Furthermore, unbalanced moisture content as a result of overdrying may render the wood more susceptible to warping.

Casehardening

The degree of casehardening in 10 samples of each thickness from each kiln charge is shown in Table 9. The results appear somewhat contradictory. Generally, more than 50 per cent of the samples examined developed a moderate to severe casehardening condition in every kiln run. Despite the tendency for casehardening to develop somewhat more severely in either the mild or moderate schedule, concrete evidence of the causes is lacking due to the limited sampling and uncontrollable variations in drying schedules. Casehardening occurs early in the drying period as a result of tension set established in the exterior layers of the wood. This condition is usually associated with drying surfaces too rapidly, either because the temperature is too high or the humidity is too low, or both. It can also result from uneven drying, when poor air circulation causes too large a fluctuation in temperature and humidity. Casehardening is usually prevented by restricting steep moisture gradients in wood during drying. The development of set, however, is a function of both

TABLE 9.—Frequency and Severity of Casehardening

Schedule and thickness	Degree of casehardening		
	None	Slight	Moderate to severe
	..... Percent of boards		
SCHEDULE A			
3/4-inch	—	40	60
4/4-inch	—	40	60
SCHEDULE B			
3/4-inch	—	10	90
4/4-inch	—	10	90
SCHEDULE C			
3/4-inch	—	40	60
4/4-inch	—	20	50
SCHEDULE D			
6/4-inch	—	—	100
8/4-inch	40	10	50
SCHEDULE E			
6/4-inch	10	30	60
8/4-inch	30	10	50
SCHEDULE F			
6/4-inch	10	—	90
8/4-inch	—	10	90

time-temperature and time-load effects.[3] This phenomenon, as it relates to drying behavior, is not yet understood.

Surface Checking

The frequency and severity of surface checking that occurred in 10 samples in each kiln charge are presented in Table 10. Both the 3/4-inch and the 4/4-inch lumber had very few surface checks when dried with schedule A, but more checks developed with schedules B and C because higher temperatures and lower humidities were used in these schedules. The resultant effects of lower humidity are a steeper moisture gradient and greater tensile stress in the surface layers of the wood. When these effects are accompanied by high temperature, the wood is further weakened so that more surface checks develop. A comparison shows that the 4/4-inch lumber developed more checks than the 3/4-inch lumber, probably because of a steeper moisture gradient in the thicker lumber when the drying rates for the two thicknesses were the same.

In the 6/4-inch and 8/4-inch lumber group, the thinner lumber had more checks. The reason may be the drying rate of the 8/4-inch lumber, which was slower and resulted in less moisture gradient than in the 6/4-inch lumber. The severe drying schedule likewise caused more checking than the mild drying schedule.

TABLE 10.—Frequency and Severity of Surface Checking

Schedule and thickness	Number of checks			
	0	1–5	6–15	16+
	Percent of board faces			
SCHEDULE A				
3/4-inch	95	5	0	0
4/4-inch	95	5	0	0
SCHEDULE B				
3/4-inch	90	0	10	0
4/4-inch	80	15	5	0
SCHEDULE C				
3/4-inch	95	5	0	0
4/4-inch	70	5	25	0
SCHEDULE D				
6/4-inch	0	90	10	0
8/4-inch	65	30	5	0
SCHEDULE E				
6/4-inch	10	75	10	5
8/4-inch	85	10	5	0
SCHEDULE F				
6/4-inch	0	80	20	0
8/4-inch	15	10	65	10

[3] J. M. McMillen (1958). Stresses During the Drying of Lumber. U.S. Forest Products Laboratory, Report No. 1652, Madison, Wisconsin.

Conclusions

From this investigation the following conclusions are drawn:

1. Three-quarter-inch southern pine may be dried using schedules similar to those used for 4/4-inch lumber.

2. Such schedules (AS11-BK6, AS11-AK6, and AS12-AK8) resulted in faster drying rates and shorter drying times for 3/4-inch lumber as compared with those for 4/4-inch lumber.

3. Seasoning degrade (warping, casehardening, and checking) was generally less in 3/4-inch lumber than in 4/4-inch lumber, except in the case of casehardening under the more severe drying schedule.

4. Shrinkage in thickness of 3/4-inch lumber was 63 per cent of that of 4/4-inch lumber.

5. Six-quarter-inch lumber dried at considerably faster rates and in shorter times than 8/4-inch lumber under similar drying schedules.

6. The schedules used (AS10-AK4, AS11-AK6, and AS12-AK8) generally resulted in greater seasoning degrade (warping, casehardening, and checking) in 6/4-inch lumber than in 8/4-inch lumber, indicating the need for caution in selection of drying schedules for the thinner of these two thicknesses.

7. There was less shrinkage in length and more shrinkage in width in 6/4-inch lumber than in 8/4-inch lumber.

8. A moderate schedule is advisable for fast drying. However, 3/4-inch lumber can be dried using a more severe schedule without developing defects that exceed economically acceptable levels. A severe schedule is not advisable for 6/4-inch lumber because of excessive losses from degrade.

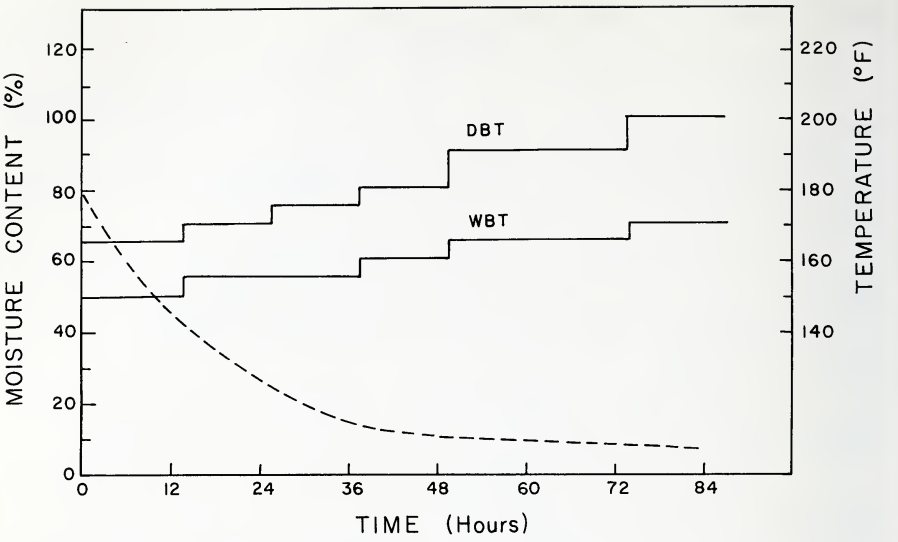

FIGURE 6.—Kiln schedule and drying rate. Schedule A, ¾-inch lumber.

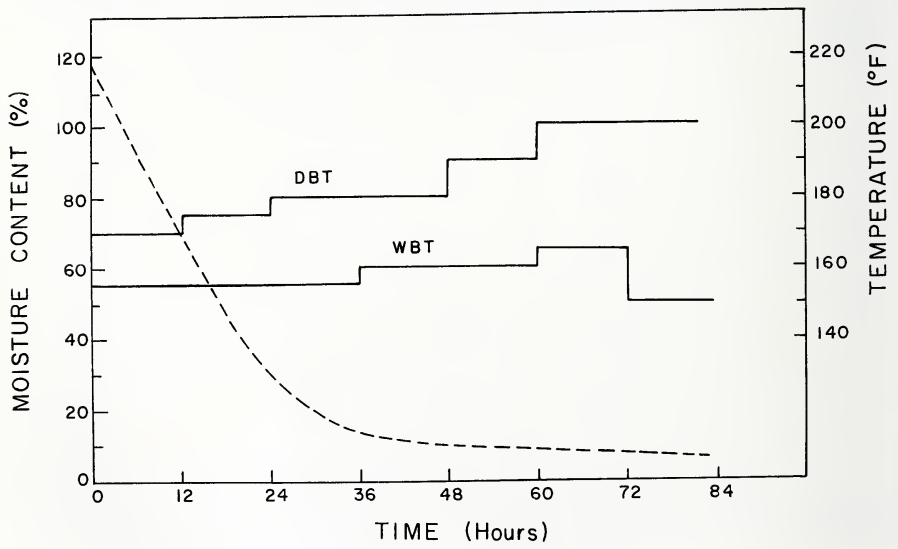

FIGURE 7.—Kiln schedule and drying rate. Schedule B, ¾-inch lumber.

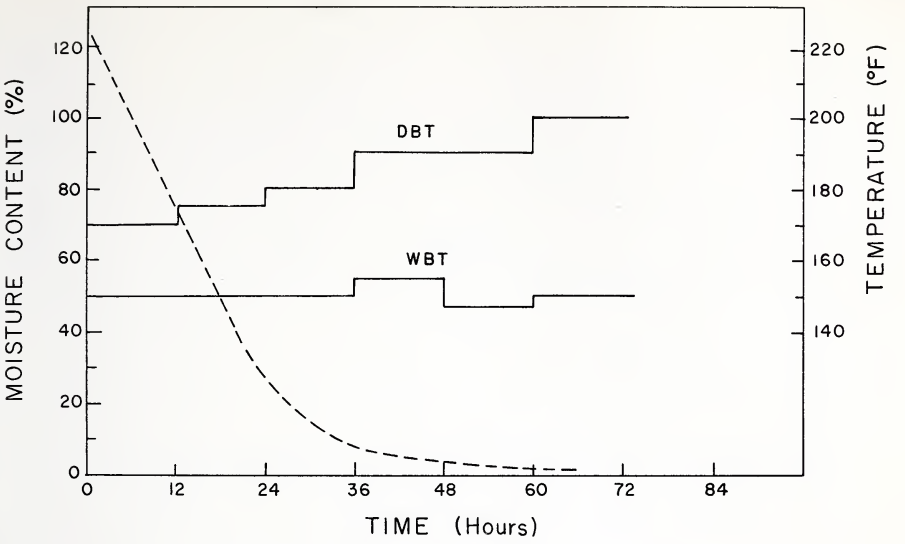

FIGURE 8.—Kiln schedule and drying rate. Schedule C, ¾-inch lumber.

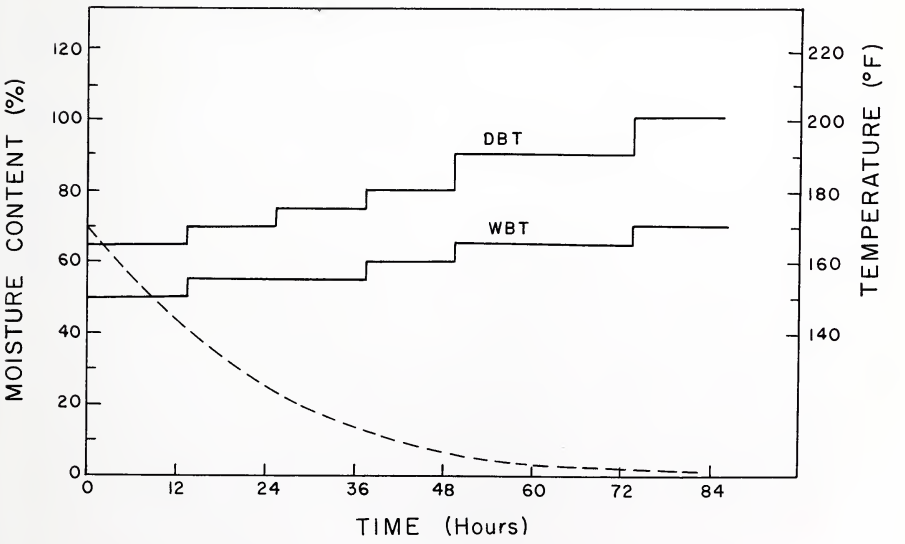

FIGURE 9.—Kiln schedule and drying rate. Schedule A, 4/4-inch lumber.

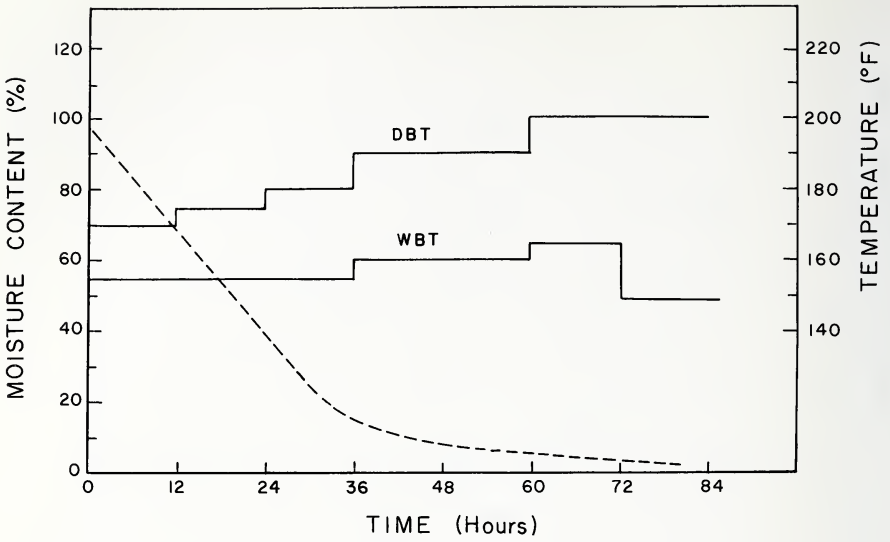

FIGURE 10.—Kiln schedule and drying rate. Schedule B, 4/4-inch lumber.

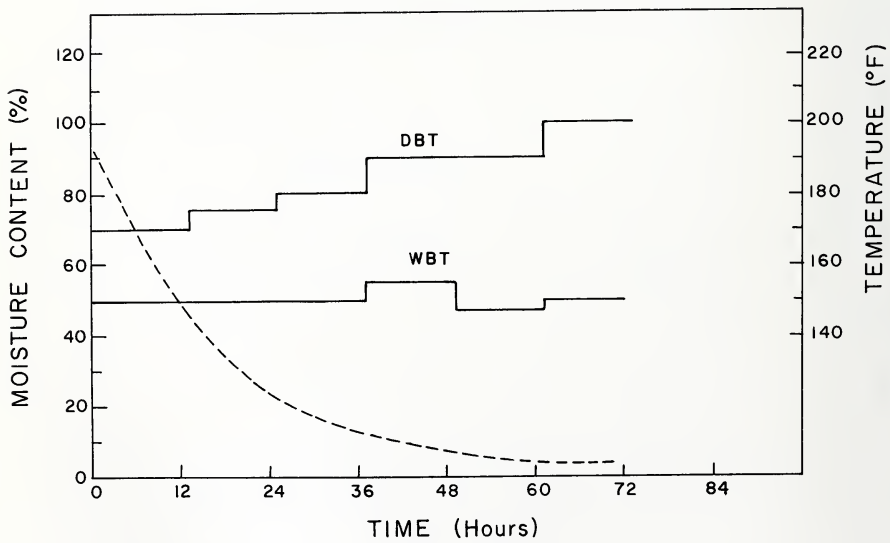

FIGURE 11.—Kiln schedule and drying rate. Schedule C, 4/4-inch lumber.

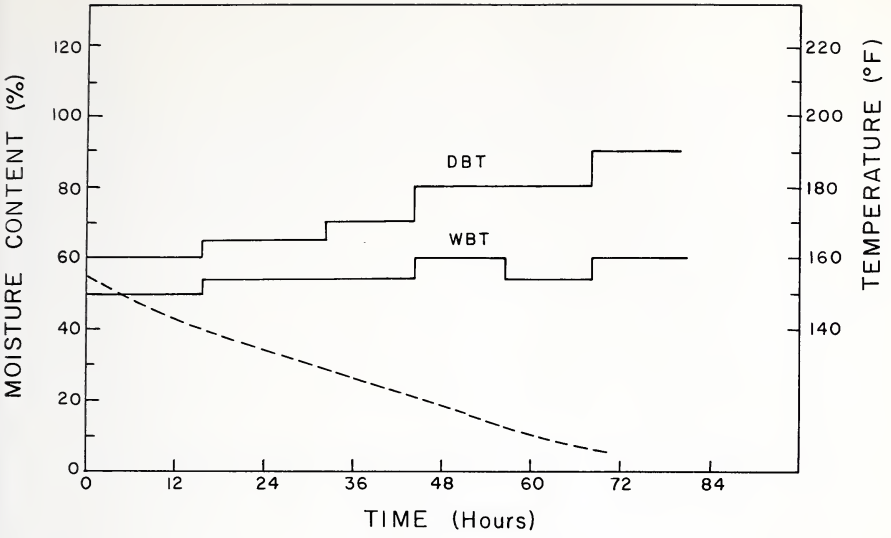

FIGURE 12.—Kiln schedule and drying rate. Schedule D, 6/4-inch lumber.

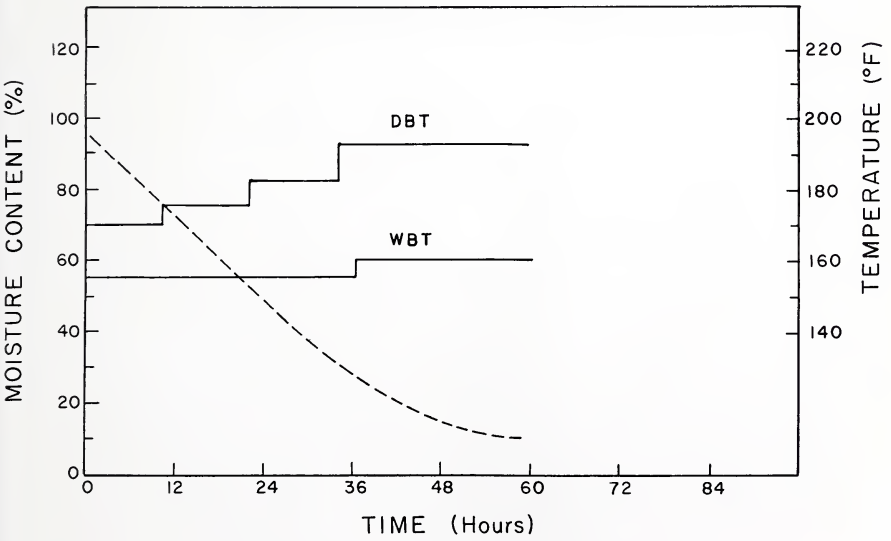

FIGURE 13.—Kiln schedule and drying rate. Schedule E, 6/4-inch lumber.

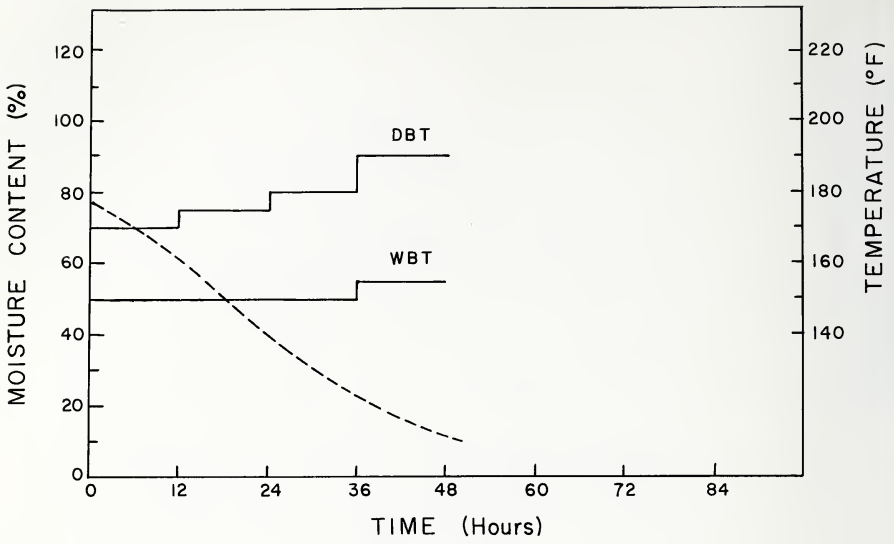

FIGURE 14.—Kiln schedule and drying rate. Schedule F, 6/4-inch lumber.

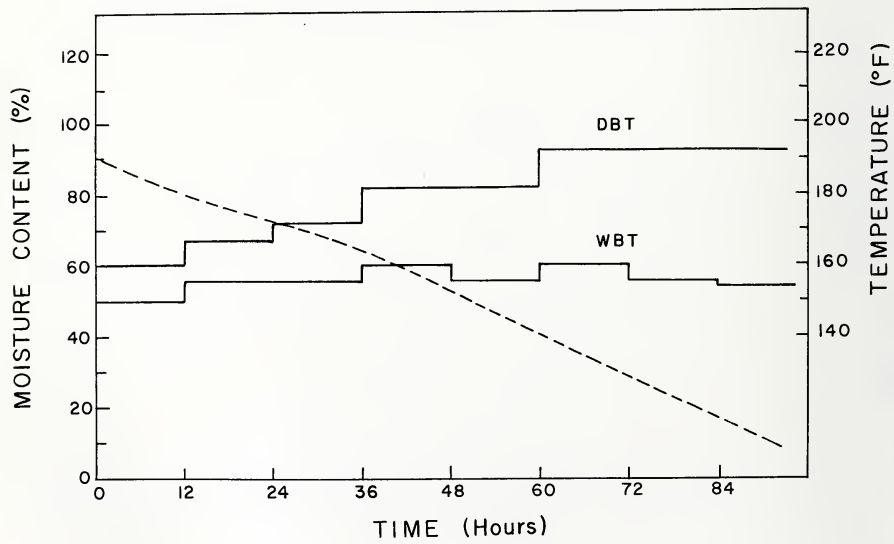

FIGURE 15.—Kiln schedule and drying rate. Schedule D, 8/4-inch lumber.

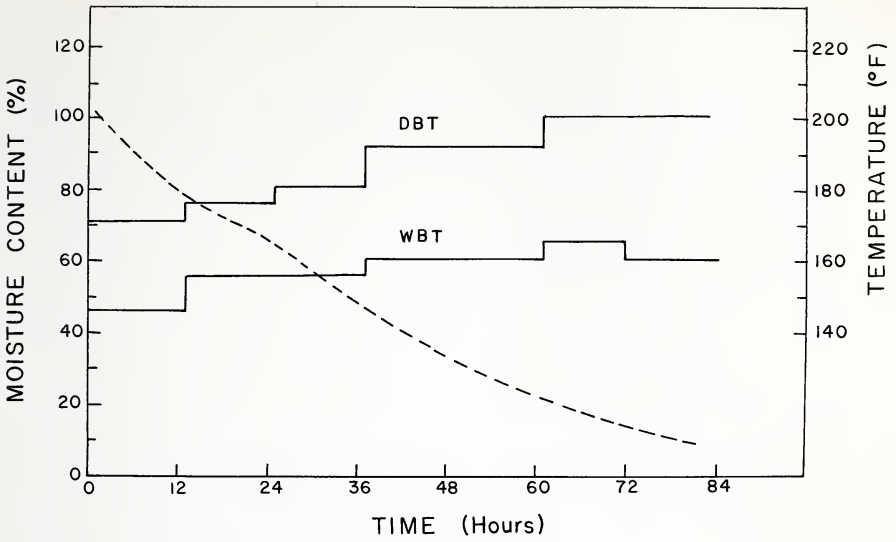

FIGURE 16.—Kiln schedule and drying rate. Schedule E, 8/4-inch lumber.

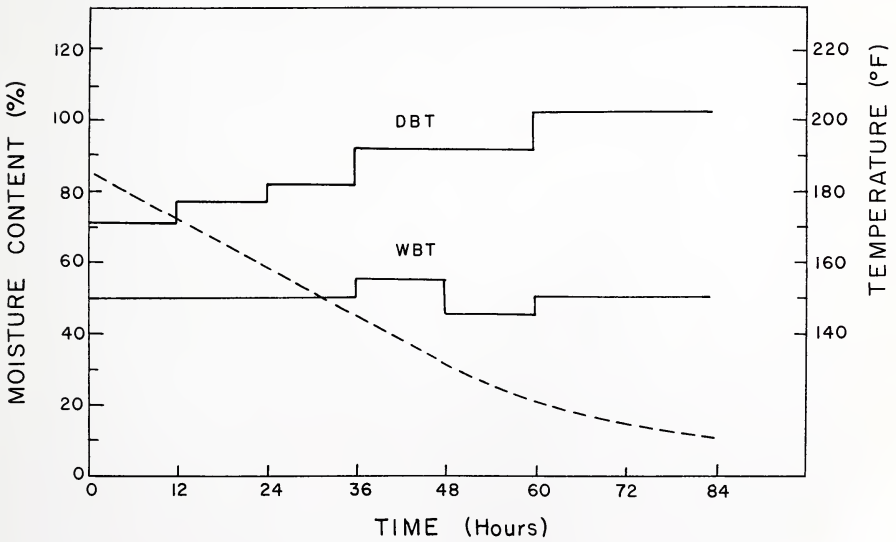

FIGURE 17.—Kiln schedule and drying rate. Schedule F, 8/4-inch lumber.